§71. Effects of Plasma Exposure on Tritium Behavior of Plasma Facing Materials

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It is of importance to clarify phenomena of implantation, retention, diffusion and permeation of tritium on surface of the armor materials of the first wall/blanket and the divertor from a viewpoint of precise control of fuel particles, reduction of tritium inventory and safe waste management of materials contaminated with tritium. In addition, it is well known that re-deposited layer, which includes the first wall components emitted by sputtering and residual gases such as oxygen, is formed. On the other hand, tungsten would be used as the armor material of the first wall and divetor in demo reactor. Therefore, clarification of behavior of tritium on surface exposed by plasma in all metallic first wall and divertor needs to be made. In the present work, tritium exposure experiments have been carried out for long term installed samples on first wall in spherical tokamak QUEST, which is an all metallic first wall device.

Samples have been installed on vacuum chamber of spherical tokamak QUEST in Kyushu University. The vacuum vessel, and an armor of divertor and center stack of QUEST are made of SUS316L and tungsten, respectively. After the plasma discharge experiments, the samples have been examined using XPS, RBS and ERD. In addition, tritium exposure experiments have been carried out using a tritium (T) exposure device in University of Toyama. Pressure of the T gas was 1.3 kPa and T exposure was kept for 4 h in all examinations. T concentration in the gas was about 5 %. After thermal exposure to T gas, T amount retained in surface layers of the sample was evaluated by β-ray-induced X-ray spectrometry (BIXS) and imaging plate (IP) measurements.

Results from XPS analyses on the SUS316L sample which was installed in the 3rd cycle (from 2009/11 to 2010/4) showed that re-deposited layer was formed and main composition was C. BIXS measurement which temperatures of pre-heating and T exposures were 400 °C and 350 °C, respectively showed that Fe(Kα) etc. peaks originated from composition of SUS6316L in addition to Ar(Kα) peak, originated from β ray on T near surface of SUS316L, were detected. IP measurement indicated that amount of T on the re-deposited sample at RT and 350 °C exposure was 4.6 and 2.5 times higher than that of non-exposure sample in QUEST. On the other hand, re-deposited layer, which main composition was Fe, Cr, W and O, was formed on SUS316L sample which was installed in the 7 th cycle (from 2011/10 to 2012/4). Figure 1 shows tritium images of samples which were installed at the 7th cycle in the first wall in QUEST. Amount of T on the re-deposited sample which temperatures of pre-heating and T exposures were both 100 °C (same temperature of wall during plasma discharge experiment in QUEST) was 8.5 times higher than that of non-exposure sample in QUEST. In addition, results from T exposure experiments using IP are summarized in Fig. 2. These results indicate that formation on re-deposited layer enhances T retention, and amount of T must be evaluated taking into account the re-deposited layer.

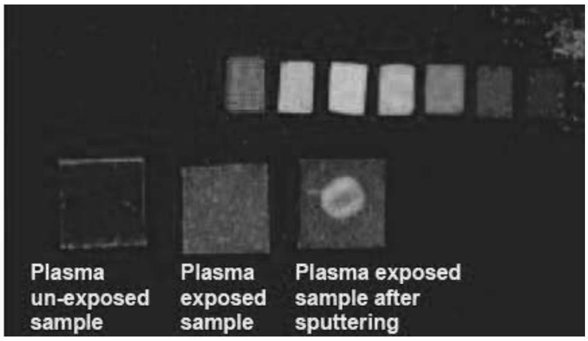

Fig. 1. Tritium images of samples exposed to T gas at 100 °C.

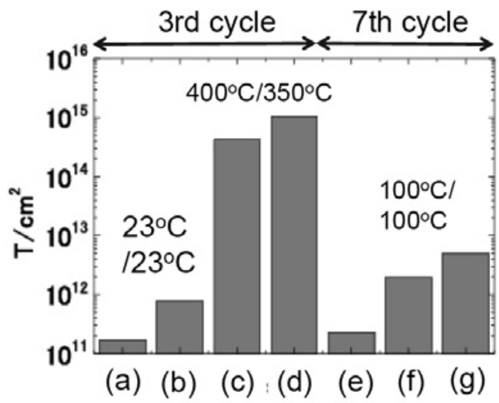

Fig. 2. Amount of T retention of various samples.
(a)Plasma un-exposed sample, pre-heating : 23°C, T exposure : 23°C.
(b)3rd cycle plasma exposed sample, pre-heating:23°C, T exposure : 23°C.
(c)Plasma un-exposed sample, pre-heating : 400°C, T exposure : 350°C.
(d)3rd cycle plasma exposed sample, preheating : 400°C, T exposure : 350°C.
(e)Plasma un-exposed sample, pre-heating:100°C, T exposure : 100°C.
(f)7th cycle plasma exposed sample, pre-heating : 100°C, T exposure : 100°C.
(g)7th cycle plasma exposed sample after sputtering, pre-heating:100°C, T exposure : 100°C.